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Distribution Patterns of Remaining Hydrocarbons Controlled by Reservoir Architecture of Distributary Channel with Different Channel Style: S2 Formation of Songliao Basin, China

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1 Introduction

Reservoir architecture analysis of distributary channel of Daqing oilfield has drawn consistent interest among development geologists and petroleum engineers over the last decade (Lv et al., 1999; Zhou et al., 2008; Zhang et al., 2013) since the theory of architectural-element analysis was proposed and developed (Allen, 1983; Miall, 1985). Numerous studies in terms of the theory of architectural-element analysis and depositional model have been carried out to characterize the distributary channel architecture which governs paths of fluid migration during oil and gas production (Gardner et al., 1992; Bridge et.al, 2000) and their study is considered pivotal for the aim of locating and recovering the remaining hydrocarbons. However, the channel style, exercising fundamental control on the geometry and heterogeneity of distributary channel (Davies et al., 1993), is relatively less taken into consideration when analyzing the reservoir architecture. Also, the remaining oil volumes within the channel have been paid much attention by geologists and petroleum engineers while those distributing in interchannel overbank sandstones have been largely overlooked. In fact, a comprehensive understanding of distribution patterns of remaining hydrocarbons controlled by reservoir internal architecture of interchannel overbank sandstones can provide considerable incremental reserves for the field life extension of Daqing oilfield.

Therefore, this paper focuses first on the differences in reservoir architecture characteristics that occur between distributary channel sandstones with contrasting channel style: high sinuosity distributary channel (HSDC) and low sinuosity distributary channel (LSDC). Then this paper investigates the various types of remaining oil which are strongly controlled by complex reservoir architecture between two sorts of distributary channel.

2 Reservoir architecture analysis

Distributary channel sandstones with different channel type have various depositional characteristics, geometry and heterogeneity. Channel style should be determined before delineating the reservoir architecture based on previous study on depositional environment and integrated analysis with cores, outcrops and wireline-logs from the close well-spacing area in Daqing oilfield, China. The results are as follows: (a) the sinuosity of HSDC is greater than 2(Liu, 1980). HSDC is characterized principally with the lateral accretion and the development of point bar and abandoned channel. Shale drapes on the lateral-accretion surface within point bar and abandonment clay plug within abandoned channel, acting as baffles and barriers to hydrocarbon flow, are the main reasons of reservoir heterogeneity. (b) While the sinuosity of LSDC is less than 2(Liu, 1980) and the point bar and abandoned channel are relatively undeveloped as well as the lateral accretion. LSDC is characterized primarily with small channel and interchannel overbank sandstones originating in the process of river overflowing from channel at flooding stage. The contact relationships among channels and connectivity quality between channel and interchannel overbank sands are the major reasons of reservoir heterogeneity.

This paper carries out the architectural-elements analysis using the method of hierarchical analysis and the guidance of depositional model in conjunction with cores and wireline-logs data. This workflow involves two principal steps as the following: (1) the identification of

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architectural elements and bounding surfaces within individual well; (2) the prediction of distributions of architectural elements and bounding surfaces between wells with reference to the different depositional models and geological knowledge database. The reservoir architectures of HSDC and LSDC are characterized by employing the approaches above, indicating the reservoir architecture characteristics of jigsaw-puzzle and labyrinth (Webber et.al, 1990), respectively. Furthermore, the three-dimensional architectural-elements model is established based on the accomplishments above by adopting the methods of integrated sequential indicator simulation and human-computer interaction.

3 Remaining oil distribution patterns

Based on the outcomes of reservoir architecture in this study, the areal and sectional water cut maps which could reveal the unswept areas to help locate the remaining oil are established in conjunction with sealed coring wells and water-cut well-log interpretation results. Eventually, the distribution patterns of remaining oil controlled by reservoir architecture are summarized with the evidences from the results of reservoir simulation on basis of three-dimensional architectural-elements model. The patterns are as follows: (1) remaining oil controlled by complex reservoir architecture with relatively perfect injection-production systems: the remaining oil volumes in HSDC controlled by shale drapes on the lateral-accretion surface within point bar and abandonment clay plug are mainly distributed in top of point bars and beside the abandonment clay plug. Nevertheless, the remaining oil volumes controlled by labyrinthic configurations among individual channels and interchannel overbank sandstones and complex contact relationships between individual channels are primarily distributed in the top of channels and low-permeability interchannel overbank sandstones creating slow oil. (2) remaining hydrocarbons caused by relatively imperfect injection-production systems: small isolated sandstones and local sand pinch-outs with the sedimentological dead-ends of interchannel sands developing trapped oil (Gill et al., 2010) and channel margins leading to banked oil (Shepherd, 2009) in both HSDC and LSDC reservoirs.

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